MarLIN
Marine Information Network
Information on the species and habitats around the coasts and sea of the British Isles

Baltic tellin (*Limecola balthica*)

MarLIN – Marine Life Information Network
Biology and Sensitivity Key Information Review

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2001-12-19

A report from:
The Marine Life Information Network, Marine Biological Association of the United Kingdom.

Please note. This MarESA report is a dated version of the online review. Please refer to the website for the most up-to-date version [https://www.marlin.ac.uk/species/detail/1465]. All terms and the MarESA methodology are outlined on the website (https://www.marlin.ac.uk)

This review can be cited as:
Budd, G.C.& Rayment, W.J. 2001. *Limecola balthica* Baltic tellin. In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom.
DOI https://dx.doi.org/10.17031/marlinsp.1465.1

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Limecola balthica.
Photographer: Dr W.J. Langston

See online review for distribution map

Distribution data supplied by the Ocean Biogeographic Information System (OBIS). To interrogate UK data visit the NBN Atlas.

Researched by	Georgina Budd & Will Rayment	**Refereed by**	Dr Bill Langston
Authority	(Linnaeus, 1758)		
Other common names	-	**Synonyms**	*Macoma balthica* (Linnaeus, 1758)

Summary

Description

Limecola balthica is widely distributed throughout north-west Europe and Britain. It has a plump almost circular shell, up to 25 mm in length, with umbones close to the midline. The posterior of the shell may be very slightly tapered. The colour of *Limecola balthica* varies between pink, purple, yellow, white and may be blackened in sulphide-rich sediments. The colour is either uniform throughout the shell or in concentric bands.

Recorded distribution in Britain and Ireland

Common in estuarine environments around the British Isles, with the exception of the south coast.

Global distribution

Limecola balthica has an extensive geographic range that reaches from temperate to arctic coastal waters in both the North Atlantic and North Pacific oceans.

Habitat

Limecola balthica lives a few centimetres below the surface of sand, mud and muddy sand. It is found from the upper regions of the intertidal into the sublittoral, particularly in estuaries and on tidal flats.

Depth range

1-190m

Identifying features

- Shell equivalve and broadly oval, up to 25 mm long.
- Umbones more or less on mid-line.
- Anterior hinge line and margin regularly convex, posterior hinge line and margin slightly attenuated.
- Periostracum colourless or light brown, most conspicuous at margins.
- Pallial sinus irregular, deep, lower edge largely fused with pallial line.
- Two small cardinal teeth in each valve, no lateral teeth.
- Outer surface dull, with sculpturing of fine, concentric banding.
- Shell pink, purple, white or yellow in various shades, unicolorous or banded; inner surface similar.
- Outer surface may be blackened in sulphide-rich sediments.

Additional information

-none-

Listed by

Further information sources

Search on:

NBN WoRMS

Biology review

Taxonomy

Phylum	Mollusca Snails, slugs, mussels, cockles, clams & squid
Order	Cardiida
Family	Tellinidae
Genus	Limecola
Authority	(Linnaeus, 1758)
Recent Synonyms	Macoma balthica (Linnaeus, 1758)

Biology

Typical abundance	High density
Male size range	< 25mm
Male size at maturity	3-6mm
Female size range	3-6mm
Female size at maturity	
Growth form	Bivalved
Growth rate	3mm/year
Body flexibility	None (less than 10 degrees)
Mobility	
Characteristic feeding method	Active suspension feeder, Surface deposit feeder
Diet/food source	
Typically feeds on	Diatoms, deposited plankton, suspended phytoplankton & detritus.
Sociability	
Environmental position	Infaunal
Dependency	No information found.
Supports	No information
Is the species harmful?	No

Biology information

Abundance

Stephen (1929) reported typical abundances of *Limecola balthica* (as *Macoma balthica*) from the Firth of Forth to be 0-89/m^2 and maximum abundance to be 288/m^2. Ratcliffe *et al.* (1981) reported adult densities in the Humber Estuary, UK, between 5,000/m^2 and 40,000/m^2 depending on time since a successful spatfall. Bonsdorff *et al.* (1995) reported juvenile density in the Baltic Sea following settlement to be 300,000/m^2 decreasing to a stable adult density of 1,000/m^2.

Size at maturity

Caddy (1967) reported *Limecola balthica* (as *Macoma balthica*) from the River Thames reaching maturity in their 2nd year at a size of 5-6mm, whereas in the Netherlands, first year animals larger than 4mm had developed gonads during the spawning season (Lammens, 1967). Lavoie (1970) (cited in Gilbert, 1978) reported that a population of *Limecola balthica* from a French estuary did not achieve sexual maturity until their second year at a mean length of 3.57mm. Given that the growth rate varies significantly between populations, Gilbert (1978) suggested that *Limecola* *balthica* may mature in its 2nd year of life regardless of size or during its first year if a certain size is achieved. Harvey & Vincent (1989), however, consider that sexual maturity is a function of size rather than age in *Limecola balthica*, maturation occurring when the shell reaches 6mm with corresponding ages of individuals from the same population varying between 10 and 22 months.

Growth rate

Gilbert (1973) reported mean annual growth rate of *Limecola balthica* to be 3.3mm/yr with an average length of 18-20mm for fully grown individuals. However, other studies show considerable variations in growth patterns in relation to habitat and depth. McLusky & Allan (1976) reported the maximum growth rate of *Limecola balthica* in the laboratory to be 1mm over an 8 month period for 5-7mm long animals maintained at 15°C and 25psu.

Toxicity

Limecola balthica is not normally considered to be toxic but may transfer toxicants through the food chain to predators. *Limecola balthica* was implicated in the Mersey bird kill in the late 1970's, owing to bioconcentration of alklyC-lead residues (Bull *et al.*, 1983).

Habitat preferences

Physiographic preferences	Ria / Voe, Estuary, Enclosed coast / Embayment
Biological zone preferences	Lower eulittoral, Mid eulittoral, Upper eulittoral
Substratum / habitat preferences	Mud, Muddy sand, Sandy mud
Tidal strength preferences	Moderately Strong 1 to 3 knots (0.5-1.5 m/sec.), Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Extremely sheltered, Sheltered, Very sheltered
Salinity preferences	Low (<18 psu), Reduced (18-30 psu), Variable (18-40 psu)
Depth range	1-190m
Other preferences	No text entered
Migration Pattern	Non-migratory / resident

Habitat Information

Studies have indicated that eastern and western North Atlantic populations of *Limecola balthica* are morphologically and genetically different from one another, and that they may have diverged as sibling species (Meehan & Carlton, 1988).

Depth preferences

Limecola balthica occurs in a wide depth range between the mid shore and 190m but is most abundant at moderate depths on muddy and sandy bottoms (Olafsson, 1986). However, in British waters *Limecola balthica* is mainly an intertidal species.

Local distribution

Limecola balthica is a resident species but because of near-surface habitat preference, populations may be subject to tidal re-location and scouring. Also observations of propulsion stimulus to scallops may assist in local relocation (Langston, W.J., pers. comm.)

Life history

Adult characteristics

Reproductive type	Gonochoristic (dioecious)
Reproductive frequency	Annual episodic

Fecundity (number of eggs)	10,000-100,000
Generation time	1-2 years
Age at maturity	See additional information
Season	See additional information
Life span	5-10 years

Larval characteristics

Larval/propagule type	-
Larval/juvenile development	Planktotrophic
Duration of larval stage	1-6 months
Larval dispersal potential	Greater than 10 km
Larval settlement period	Insufficient information

Life history information

Lifespan

Gilbert (1973) reviewed longevity records of *Limecola balthica* (as *Macoma balthica*). lifespan is typically 5-10 years but may be as long as 30 years in populations from deep, cold water. The data presented suggest that maximum size and growth rate decrease and longevity increases with increasing latitude and associated cooler temperatures.

Age at maturity

Caddy (1967) reported *Limecola balthica* from the River Thames reaching maturity in their 2nd year at a size of 5-6mm, whereas in the Netherlands, first year animals larger than 4mm had developed gonads during the spawning season (Lammens, 1967). Lavoie (1970) (cited in Gilbert, 1978) reported that a population of *Limecola balthica* from a French estuary did not achieve sexual maturity until their second year at a mean length of 3.57mm. Given that the growth rate varies significantly between populations, Gilbert (1978) suggested that *Limecola balthica* may mature in its 2nd year of life regardless of size or during its first year if a certain size is achieved. Harvey & Vincent (1989), however, consider that sexual maturity is a function of size rather than age in *Limecola balthica*, maturation occurring when the shell reaches 6mm with corresponding ages of individuals from the same population varying between 10 and 22 months.

Gametogenesis and spawning

Caddy (1967) studied gametogenesis and spawning in a population of *Limecola balthica* from the Thames Estuary, UK. The primary gonad passed through a male phase, maturation being achieved in the 2nd year of life. Gametogenesis was associated with a system of follicle cells which broke down as the gametes approached maturity. The arrangement of the follicle cells was characteristic of the sex. In the female, gametocytes were peripheral to the follicle cells, while in the male they were interstitial. Spermatogenesis proceeded most rapidly in the centre of the follicle, resulting in a gradient of spermatogenic stages of increasing maturity from the periphery to the centre. Spawning occurred principally in the spring and to a lesser extent in the autumn. Several spawnings were identified within a season, but repeated cycles of gametogenesis were absent. Ejection of eggs occurred from the exhalant siphon and continued for 40 minutes with brief spawning bursts at 3 minute intervals. Eggs were expelled at considerable speed to a height in the water column of approximately 8cm and settled out of suspension slowly. Females of approximately 17mm shell length were estimated to have expelled between 10,000 and 50,000 eggs.

Sensitivity review

This MarLIN sensitivity assessment has been superseded by the MarESA approach to sensitivity assessment. MarLIN assessments used an approach that has now been modified to reflect the most recent conservation imperatives and terminology and are due to be updated by 2016/17.

Physical Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Substratum Loss	High	High	Moderate	High

Limecola balthica inhabits the upper layers of sandy and muddy substrata in physiographic locations where activities causing substratum loss occur e.g. channel dredging. Consequently, removal of the substratum would remove the population of *Limecola balthica* from the area affected and so intolerance is assessed as high. Direct evidence of recovery by *Limecola balthica* following substratum loss is given by Bonsdorff (1984) (see additional information below) and recoverability is recorded as high.

Smothering	Tolerant	Not relevant	Not sensitive	High

Limecola balthica is an infaunal species that is able to burrow both vertically and horizontally through the substratum which it inhabits by use of its foot. It is likely that *Limecola balthica* is not sensitive to smothering by a layer of sediment 5 cm thick as it is a mobile species able to burrow upwards and surface from a depth of 5 - 6 cm (Brafield & Newell, 1961; Brafield, 1963; Stekoll *et al.*, 1980).

Increase in suspended sediment	Tolerant*	Not relevant	Not sensitive*	Moderate

Limecola balthica is known to practice two alternative modes of feeding. It either holds its feeding organ, the siphon, at a fixed position just above the sediment surface to filter out food particles suspended in the overlying water, or extends and moves its siphon around on the sediment above it to vacuum up deposited food particles (Peterson & Skilleter, 1994). Facultative switching between the modes of feeding in *Limecola balthica* is directly affected by food availability in the over-lying water (Lin & Hines, 1994). In turn, changes in feeding mode from suspension to deposit feeding directly affects burial depth and burrowing in the sediment is one of few defensive mechanisms *Limecola balthica* has against predators. In the laboratory, Lin & Hines (1994) observed specimens of *Limecola balthica* kept in estuarine water supplemented with 75 µg $L^{-1}$of algae to maintain a deeper burial position whilst suspension feeding, than those without an enhanced diet who deposit fed. Thus an increase of material in suspension will favour suspension feeding by *Limecola balthica* and indirectly reduce its vulnerability to lethal and sub-lethal siphon browsing by fish and decapods. *Limecola balthica* is therefore assessed as 'tolerant' with the potential for growth and reproduction to be enhanced by the increased food supply.

Decrease in suspended sediment	Low	Very high	Very Low	Moderate

Limecola balthica is known to practice two alternative modes of feeding. It either holds its feeding organ, the siphon, at a fixed position just above the sediment surface to filter out food particles suspended in the overlying water, or extends and moves its siphon around on the sediment to vacuum up deposited food particles (Peterson & Skilleter, 1994). A reduction in suspended material is likely to decrease the availability of food attained efficiently by suspension feeding. Facultative switching between the modes of feeding in *Limecola balthica* is directly affected by food availability in the over-lying water (Lin & Hines, 1994). In turn, changes in feeding mode from suspension to deposit feeding directly affects its burial depth and burrowing in the sediment is one of few defensive mechanisms *Limecola balthica* has against predators. Thus a decrease in the amount of suspended material in the over-lying water is likely to initiate deposit feeding in *Limecola balthica*. In doing so, *Limecola balthica* may decrease the depth at which it resides in order to stretch its siphon over the substratum to feed efficiently. The exposure of its inhalent siphon (rather than just the tip) for deposit feeding is likely to increase the risk of lethal predation and non-lethal siphon browsing by fish and decapods. However, intolerance is assessed to be low since the benchmark change period is one month.

Dessication	Tolerant	Not relevant	Not sensitive	Low

Limecola balthica is a bivalve and can close tightly by contraction of the adductor muscle, storing moisture inside the shell. The silty sediments in which the species lives have a high water content and are therefore resistant to desiccation. Furthermore, *Limecola balthica* is mobile and would be able to relocate further down the shore by burrowing (Bonsdorff, 1984) or floating (Sörlin, 1988) if exposed to desiccation stress. *Limecola balthica* has therefore been assessed as 'tolerant' to desiccation at the level of the benchmark.

Increase in emergence regime	Low	Very high	Very Low	Low

Limecola balthica occurs in the upper regions of the intertidal (Tebble, 1976) and is therefore likely to be tolerant of prolonged emergence. It is a bivalve and can close tightly by contraction of the adductor muscle, storing moisture inside the shell. The silty sediments in which the species lives have a high water content and are therefore resistant to desiccation. Furthermore, *Limecola balthica* is mobile and able to relocate in the intertidal by burrowing (Bonsdorff, 1984) or floating (Sörlin, 1988). It would be expected to react to an increase in emergence by migrating down the shore to its preferred position. There may be an energetic cost to this migration but it is not expected that mortality would result and so intolerance is recorded as low. *Limecola balthica* should quickly recover from the energetic cost of relocation and so recoverability is assessed as very high.

Decrease in emergence regime	Tolerant	Not relevant	Not sensitive	High

Limecola balthica occurs in the intertidal and sublittorally down to depths of 190 m (Olafsson, 1986), although is more abundant intertidally, so would be expected to be tolerant of a decrease in emergence regime.

Increase in water flow rate	Intermediate	High	Low	Moderate

Limecola balthica thrives in low energy environments such as estuaries (Tebble, 1976) where the substratum has a high proportion of fine sediment. Increased water flow rate will change the sediment characteristics in which the species lives, primarily by re-suspending and preventing deposition of finer particles (Hiscock, 1983). This would result in erosion of the preferred habitat, which may cause mortality of some portion of the population of *Limecola balthica*. Green (1968) recorded that towards the mouth of an estuary where sediments became coarser and cleaner, *Limecola balthica* was replaced by another tellin species, *Tellina tenuis*. Intolerance is therefore recorded as intermediate. Recoverability is recorded as high (see additional information below).

Decrease in water flow rate	Tolerant	Not relevant	Not sensitive	Low

Limecola balthica thrives in low energy environments such as estuaries (Tebble, 1976) where the substratum has a high proportion of fine sediment. The species is able to maintain a feeding and respiration current independent of ambient flow. As a result of decreased water flow, rate of siltation is likely to increase, making conditions more favourable for deposit feeders. Indeed, Newell (1965) (cited in Green, 1968) noted that *Limecola balthica* populations in the Thames Estuary, UK, were denser where the grade of deposit was finer, possibly due to greater food availability. Therefore, *Limecola balthica* is probably tolerant of a decrease in water flow rate.

Increase in temperature	Low	Very high	Very Low	Moderate

The geographic range of *Limecola balthica* (see distribution) illustrates that the species is tolerant of a range of temperatures and probably becomes locally adapted. In Europe, the species occurs as far south as the Iberian Peninsula and hence would be expected to tolerate higher temperatures than experienced in Britain and Ireland. Oertzen (1969) reported that *Limecola balthica* (as *Macoma balthica*) could tolerate temperatures up to 49°C before thermal numbing of gill cilia occurred presumably resulting in death. Ratcliffe *et al.* (1981) reported that *Limecola balthica* from the Humber Estuary, UK, tolerated 6 hours of exposure to temperatures up to 37.5°C with no mortality. It seems likely therefore that the species could adapt to a chronic change and tolerate a large acute change with no mortality. The worst case scenario following an increase in temperature is an energetic cost associated with sub-optimal metabolic function and so intolerance is assessed as low. Metabolic activity should rapidly return to normal when temperatures fall to original levels so recoverability is assessed as very high.

Decrease in temperature	Tolerant	Not relevant	Not sensitive	High

The geographical distribution of *Limecola balthica* suggests that it is very tolerant of low temperature. The species occurs in the Gulfs of Finland and Bothnia where the sea freezes for several months of the year (Green, 1968). It must therefore tolerate much lower temperatures than it experiences in Britain and Ireland. Furthermore, *Limecola balthica* was apparently unaffected by the severe winter of 1962/3 which decimated populations of many other bivalve species (Crisp, 1964), and De Wilde (1975) noted that *Limecola balthica* kept at 0°C maintained a high level of feeding activity. It is unlikely therefore that UK populations of *Limecola balthica* would be intolerant of decreases in temperature.

Increase in turbidity	Low	Very high	Very Low	Low

Limecola balthica does not require light and therefore is not directly affected by an increase in turbidity for the purposes of light attenuation. An increase in turbidity may affect primary production in the water column and therefore reduce the availability of phytoplankton food in suspension and deposited at the sediment surface. However, phytoplankton will also immigrate from distant areas and so the effect may be decreased. As the benchmark turbidity increase only persists for a year, decreased food availability would probably only affect growth and fecundity and an intolerance of low is recorded. As soon as light levels return to normal, primary production will increase and hence recoverability is recorded as very high. The effect of increased siltation is detailed in 'increase in suspended sediment' above.

Decrease in turbidity	Tolerant	Not relevant	Not sensitive	Not relevant

Limecola balthica does not require light and therefore would not be affected by a decrease in turbidity for light attenuation purposes. It is possible that decreased turbidity would increase primary production in the water column and by micro-phyto benthos. The resultant increase in food availability may enhance growth and reproduction in *Limecola balthica* but only if food was previously limiting. The effect of decreased siltation is detailed in 'decrease in suspended sediment' above.

Increase in wave exposure	Intermediate	High	Low	Low

Limecola balthica characteristically inhabits fine sediments in low energy environments (Tebble, 1976). This suggests that it would, in some way, be intolerant of an increase in wave exposure. An increase in wave exposure by two categories for one year would be likely to affect the species in several ways. Fine sediments would be eroded (Hiscock, 1983) resulting in the likely reduction of the habitat of *Limecola balthica*. Strong wave action may cause damage or withdrawal of the siphons, resulting in loss of feeding opportunities and compromised growth. Furthermore, individuals may be dislodged by scouring from sand and gravel mobilized by increased wave action. For example, Ratcliffe *et al.* (1981) reported that juvenile *Limecola balthica* are susceptible to displacement by water currents due to their small mass and inability to bury deeply. For the above reasons, some mortality would be likely to occur and intolerance is recorded as intermediate. Recoverability is recorded as high (see additional information below).

Decrease in wave exposure	Tolerant	Not relevant	Not sensitive	Low

Limecola balthica characteristically inhabits muddy sand in low energy environments (Tebble, 1976). It is capable of maintaining a feeding and respiration current by ciliary action. It is therefore unlikely to be affected by a decrease in wave exposure. However, it should be noted that decreased wave exposure will lead to changes in oxygenation and increased risk of smothering due to siltation. These factors are discussed in their relevant sections.

Noise	Tolerant	Not relevant	Not sensitive	Low

Limecola balthica is intolerant of shear-wave vibrations that propagate along the sediment surface in the frequency range 50-200 Hz (Franzen, 1995). When placed on the surface of the substratum and exposed to a shear-wave of typical velocity for unconsolidated muddy sand (15 meters per second), the response of *Limecola balthica* consisted of frequent and intense digging attempts (Franzen, 1995). It is likely that *Limecola balthica* will be not sensitive to the benchmark for underwater noise as it will either remain buried or take immediate avoidance reaction by burying without a detectable effect upon the species viability.

Visual Presence	Tolerant	Not relevant	Not sensitive	Low

Limecola balthica does not have the visual acuity to detect objects and is unlikely to be sensitive to visual disturbance.

Abrasion & physical disturbance	Intermediate	High	Low	Very low

No evidence was found concerning the effect of physical abrasion on *Limecola balthica*. However, the species is not mobile enough to be able to avoid an object such as a dragging anchor or a scallop dredge and the shell is relatively thin and would probably be damaged by such an impact. It is expected that some mortality would result and therefore intolerance is assessed as intermediate. Recoverability is recorded as high (see additional information below).

Displacement	Intermediate	High	Low	Moderate

Limecola balthica is likely to be tolerant of displacement as it is able to rebury itself within 17 minutes when placed on the surface of the substratum (McGreer, 1979). However, *Limecola balthica* individuals displaced to the sediment surface are likely to suffer an increased risk of predation and some mortality may result. Intolerance is therefore recorded as intermediate. Recoverability is recorded as high (see additional information below).

Chemical Pressures

	Intolerance	Recoverability	Sensitivity	Confidence

Synthetic compound contamination High High Moderate Very low

Beaumont *et al.* (1989) concluded that bivalves are particularly sensitive to tri-butyl tin (TBT), a toxic component of antifouling paints. For example, when exposed to 1-3 µg TBT/l, *Cerastoderma edule* and *Scobicularia plana* suffered 100% mortality after 2 weeks and 10 weeks respectively. There is also evidence that TBT causes recruitment failure in bivalves, either due to reproductive failure or larval mortality (Bryan & Gibbs, 1991). However, little evidence was found concerning the effects of synthetic chemicals specifically on *Limecola balthica*. Bryan & Gibbs (1991) recorded bioaccumulation of TBT by *Limecola balthica* (as *Macoma balthica*) to be similar to *Cerastoderma edule* and *Scobicularia plana*. Langston (1978) recorded bioaccumulation of a polychlorinated biphenyl in *Limecola balthica* (as *Macoma balthica*), levels of Aroclor 1242 reached 60 ppm in 40 days. Duinker *et al.* (1983) also reported bioaccumulation of PCBs by *Limecola balthica* (as *Macoma balthica*) but made no comment on toxicity to the species. In light of the intolerance of other bivalve species, the intolerance of *Limecola balthica* to synthetic chemicals is recorded as high but with very low confidence. Recoverability is recorded as high (see additional information below).

Heavy metal contamination High High Moderate High

- Boisson *et al.* (1998) investigated the intolerance of *Limecola balthica* (as *Macoma balthica*) from two French estuaries to silver and mercury. They reported an LT_{50} for 80µg Ag/l of 9.3 days and an LT_{50} for 100µg Hg/l of 11.0 days. However, acute tests are not necessarily relevant, especially if the major route of exposure is via food /sediment (Langston, W.J., pers. comm.). They also noted that *Limecola balthica* from a contaminated estuary were more intolerant of silver than those from an uncontaminated estuary. The differing responses were attributed to the chronic stress of living in a polluted environment making clams more intolerant of subsequent exposure. *Limecola balthica* from the contaminated estuary also exhibited lower uptake rates of heavy metal stressors, which was suggested as an adaptive trait to avoid exposure to contaminants.
- Luoma *et al.* (1983) investigated the intolerance of *Limecola balthica* from different populations within San Francisco Bay to copper, in the form of seawater spiked with copper sulphate. The 10 day LC_{50} varied between 210 µg/l and 1290 µg/l. They suggested that physiological and/or genetic adaptations could be responsible for the heterogeneity of the sensitivities and added that species survival depends more on the range of adaptive capacity within the species rather than identification of a single value of lethal or sublethal toxicant concentration.
- McGreer (1979) investigated the effect of heavy metal contaminated sediments on the burrowing and avoidance behaviour of *Limecola balthica*. Exposure to estuarine sediments containing high levels of heavy metals (Cu, Pb, Zn, Cr, Ag, Hg, Cd and Fe) caused inhibited burrowing behaviour in all contaminated sediments compared to the control. The time for 50% of the experimental population to burrow into the sediment core ranged from 0.17 hours in the control to 4.8 hours in the most contaminated substrata. Correlative evidence of the concentrations of individual metals in the sediment versus the burrowing response times suggests the inhibition of burrowing by *Limecola balthica* to be significant for Hg and Cd. The ecological significance of inhibited burrowing is very clear; exposure to predators and wave action. The significance of the avoidance response remains to be tested in the field but McGreer (1979) demonstrated that *Limecola balthica* may actively avoid sediments which become contaminated.
- Bryant *et al.* (1985 & 1985a) present evidence that the environmental variables of

temperature and salinity should be considered when evaluating the toxicity of arsenic, nickel and zinc to *Limecola balthica* in the estuarine environment. The median survival time of *Limecola balthica* exposed to Ni and Zn (range 15 - 2000 ppm) decreased as salinity decreased (from 35 psu to 5 psu in 5 psu increments). Whilst, temperature changes had greater influence on the effect of As concentration upon *Limecola balthica*.

There is evidence, therefore, of lethal and sublethal effects of exposure to heavy metals. Intolerance of *Limecola balthica* is, therefore assessed as high. Recoverability is recorded as high, assuming contaminant levels return to normal. Please see additional information below. For reference, the lethal copper concentrations reported by Luoma *et al.* (1983) are similar to copper concentrations in freshwater inputs to the Fal Estuary, UK, reported by Bryan & Gibbs (1983).

Hydrocarbon contamination	High	High	Moderate	High

Stekoll *et al.* (1980) exposed *Limecola balthica* (as *Macoma balthica*) to Prudhoe Bay crude oil in flowing seawater for six months at three concentrations; low 0.03 mg/l, medium 0.3 mg/l and high 3.0 mg/l. *Limecola balthica* exhibited a range of behavioural, physical, physiological and biochemical changes prior to death at the highest concentration of oil.
Mortality:

- Total cumulative mortality of *Limecola balthica* in control tanks after six months was 3.1%.
- *Limecola balthica* in 0.03 mg/l oil had a similar mortality of 3.2% after six months exposure.
- In the 0.3 mg/l oil treatment the mortality rate was already significantly different from the control by day 120. Mortality reached 8% by day 180.
- *Limecola balthica* in 3.0 mg/l began to die by day 30 of the experiment and after six months mortality had reached 81%.

Other observations:

- Exposure to 0.03 mg/l of oil inhibited growth and caused reabsorption of the gametes, whilst exposure to 0.3 and 3.0 mg/l of oil caused abnormalities in the gonads.
- *Limecola balthica* exposed to 0.3 and 3.0 mg/l of oil fed less actively, whilst specimens in the 3.0 mg/l oil treatment rarely extended their siphons at all.
- After one week of exposure to 0.3 and 3.0 mg/l of oil *Limecola balthica* began to burrow upwards out of the sand. Those exposed to 3.0 mg/l of oil stayed on the surface and progressively more animals surfaced throughout the duration of the experiment so that 90% had surfaced by the end of the experiment. It was not until day 90 that *Limecola balthica* in the 0.3 mg/l oil treatment began to surface in significant numbers.
- *Limecola balthica* in 3.0 mg/l of oil were also less able to orientate themselves with respect to the surface of the sand. They extruded their feet in various directions but were unable to penetrate the sand.
- For a more detailed summary of other effects particularly those of a biochemical nature, refer to Table 4 in Stekoll *et al.*, (1980).
  Stekoll *et al.* (1980) concluded that chronic exposure of *Limecola balthica* to oil-in-seawater concentrations even as low as 0.03 mg/l would in time lead to population decreases.
  Shaw *et al.* (1976) also reported mortality of *Limecola balthica* caused by exposure to

crude oil following an experimental application of oil at a concentration of 1.2 µl oil/cm□ and 5.0 µl oil/cm□ to sediments which equated to oil spills of one ton /20 km□ and one ton/100 km□. Significant mortalities were observed after only two days following application of the oil at a concentration of 5.0 µl oil./cm□. Some specimens of *Limecola balthica* survived the application of oil in these experiments but were weakened. The clams in the study of Stekoll *et al.* (1980) were not subjected to any of the stresses that normally occur in their natural environment on mudflats such as changes in salinity, temperature, oxygen availability and wave action, therefore it is possible that exposure of *Limecola balthica* to oil under field conditions results in higher mortality. Intolerance of *Limecola balthica* is therefore assessed as high. Recoverability is recorded as high assuming contamination removed (see additional information below).

Radionuclide contamination		Not relevant		Not relevant

Hutchins *et al.* (1998) described the effect of temperature on bioaccumulation by *Limecola balthica* of radioactive americium, caesium and cobalt, but made no comment on the intolerance of the species. Insufficient information was available to assess the intolerance of *Limecola balthica* to radionuclide contamination.

Changes in nutrient levels	Tolerant*	Not relevant	Not sensitive*	Moderate

It has been suggested that *Limecola balthica* has the potential to be used as an indicator organism of organic pollution (Pearson & Rosenberg, 1978; Pekkarinen, 1983; Mölsa, 1986), as the species was reported to increase in abundance towards the sources of nutrient enrichment and to disappear when the organic loading became heavier (Anger, 1975 (a) & (b); Landner *et al*., 1977). Madsen & Jensen (1987) reported the population of *Limecola balthica* to increase in abundance and biomass at two localities in the Danish Wadden Sea experiencing nutrient enrichment caused by a waste water discharge. The increase in shell growth, productivity / biomass ratio and improvement in 'condition' index of *Limecola balthica* in the organically enriched areas was presumably due to the increased food supply (Madsen & Jensen, 1987). Owing to this evidence and that *Limecola balthica* is relatively tolerant to deoxygenation (an indirect effect of nutrient enrichment) it is likely that *Limecola balthica* will benefit from nutrient enrichment.

Increase in salinity	Low	Very high	Very Low	High

McLusky & Allan (1976) conducted salinity survival experiments with *Limecola balthica* (as *Macoma balthica*) over a period of 150 days. No deaths were reported in specimens of *Limecola balthica* maintained at 30.5 psu for the duration of the experiment. *Limecola balthica* is found in brackish and fully saline waters (although it is more common in brackish waters) (Clay, 1967(b)) so may tolerate a state of flux. McLusky & Allan (1976) reported that *Limecola balthica* failed to grow at 41 psu, but it is likely that *Limecola balthica* would be tolerant of increased salinity and intolerance to a change in this factor is likely to be low. Growth should quickly return to normal when salinity returns to original levels and so recoverability is recorded as very high.

Decrease in salinity	Low	Very high	Very Low	High

McLusky & Allan (1976) conducted salinity survival experiments with *Limecola balthica* (as *Macoma balthica*) over a period of 150 days. Survival times declined with decreased salinity. At 12 psu specimens survived 78 days, whilst specimens at 8.5 psu survived 40 days. Some specimens of *Limecola balthica* survived 2.5 days at 0.8 psu, which was apparently due to the animals ability to clamp its valves shut in adverse conditions. McLusky & Allan (1976) also reported that *Limecola balthica* failed to grow (increase shell length) at 15 psu. *Limecola balthica* is found in brackish and fully saline waters (Clay, 1967(b)) so may tolerate a state of flux. Its distribution in combination with the experimental evidence of McLusky & Allan (1976) suggests that *Limecola balthica* is likely to be very tolerant to a decreased salinity over a short period. A decline in salinity in the long term may have implications for the species viability in terms of growth, and the distribution of the species may alter as specimens at the extremes retreat to more favourable conditions. Intolerance is therefore assessed as low. Metabolic function should quickly return to normal when salinity returns to original levels and so recoverability is recorded as very high. Decreased salinity may also affect the ability of *Limecola balthica* to tolerate contaminants such as heavy metals (see Bryant *et al.*, 1985 & 1985a). Usually, contaminants become more toxic at low salinity (Langston, W.J. pers comm.).

Changes in oxygenation	Low	Very high	Very Low	High

Limecola balthica appears to be relatively tolerant of deoxygenation. Brafield & Newell (1961) frequently observed that in conditions of oxygen deficiency (e.g. less than 1 mg O_2/l) *Limecola balthica* moved upwards to fully expose itself on the surface of the sand. Specimens lay on their side with the foot and siphons retracted but with valves gaping slightly allowing the mantle edge to be brought into full contact with the more oxygenated surface water lying between sand ripples. In addition, *Limecola balthica* was observed under laboratory conditions to extend its siphons upwards out of the sand in to the overlying water when water was slowly deoxygenated with a stream of nitrogen. The lower the oxygen concentration became the further the siphons extended. This behaviour, an initial increase in activity stimulated by oxygen deficiency, is of interest because the activity of lamellibranchs is generally inhibited by oxygen deficient conditions (Brafield & Newell, 1961). Dries & Theede (1974) reported the following LT_{50} values for *Limecola balthicaa* maintained in anoxic conditions : 50 - 70 days at 5°C, 30 days at 10°C, 25 days at 15°C and 11 days at 20°C. Theede (1984) reported that the ability of *Limecola balthica* to resist extreme oxygen deficiency was mainly due to cellular mechanisms. Of considerable importance are sufficient accumulations of reserve compounds e.g. glycogen and the ability to reduce energy requirements for maintenance of life by reducing overall activity (Theede, 1984). *Limecola balthica* is therefore very tolerant of hypoxia, although it may react by reducing metabolic activity. Intolerance is therefore assessed as low. Metabolic function should quickly return to normal when normoxic levels are resumed and so recoverability is recorded as very high.

Biological Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Introduction of microbial pathogens/parasites	Intermediate	High	Low	High

Limecola balthica is host to at least three gymnophallid trematodes; *Lacunovermis macomae* (Lebour), *Gymnophallus gibberosus* (Loos-Franc) and *Parvatrema affinis* which is known to cause sexual castration (Swennen & Ching, 1974). Specimens tend to be more infested at higher levels of the intertidal (1.0 m above mean low water) than at mean low water, and larger specimens tend to be more infested than smaller ones (Lim & Green, 1991). Lim & Green (1991) also suggest that increased exposure of *Limecola balthica* at the higher intertidal level to shore birds (the final host of the trematodes) is the reason for the differences in parasite load between the tidal levels. They found that the most parasitised specimens grew faster and larger than the less parasitised. Enhanced stomatic growth as a result of parasitic castration was proposed as a logical explanation to account for the faster growth rate of parasitised specimens. Recoverability is recorded as high (see additional information below).

Introduction of non-native species		Not relevant		Not relevant

There is no evidence to suggest that *Limecola balthica* is likely to be susceptible to displacement by invasive species.

Extraction of this species	Not relevant	Not relevant	Not relevant	Not relevant

Limecola balthica is not extracted commercially.

Extraction of other species	Intermediate	High	Low	Low

Commercial extraction of other infaunal species is likely to have an effect on *Limecola balthica* where their distributions overlap. Hall & Harding (1997) demonstrated that commercial cockle harvesting by suction dredging had significant effects on soft-sediment infaunal communities. Following dredging, species numbers were reduced by up to 30% and abundances by up to 50%. Bait harvesting has also been shown to impact infaunal bivalves. For example, mechanical harvesting for *Arenicola marina* resulted in drastic reduction in the population of *Mya arenaria* in the Wadden Sea (Beukema, 1995), and commercial digging of mudflats in Maine, USA, reduced total number of infaunal taxa (Brown & Wilson, 1997). Some mortality of *Limecola balthica* may occur therefore due to harvesting of other species so an intolerance of intermediate is recorded. Recoverability is recorded as high (see additional information below).

Additional information

The life history characteristics of *Limecola balthica* give the species strong powers of recoverability. Adults spawn at least once a year and are highly fecund (Caddy, 1967). There is a planktotrophic larval phase which lasts up to 2 months (Fish & Fish, 1996) and so dispersal over long distances is potentially possible given a suitable hydrographic regime. Following settlement, development is rapid and sexual maturity is attained within 2 years (Gilbert, 1978; Harvey & Vincent, 1989). In addition to larval dispersal, dispersal of juveniles and adults occurs via burrowing (Bonsdorff, 1984; Guenther, 1991), floating (Sörlin, 1988) and probably via bedload transport (Emerson & Grant, 1991). It is expected therefore that recruitment can occur from both local and distant populations.

Bonsdorff (1984) studied the recovery of a *Limecola balthica* (as *Macoma balthica*) population in a shallow, brackish bay in SW Finland following removal of the substratum by dredging in the summer of 1976. Recolonization of the dredged area by *Limecola balthica* began immediately after the disturbance to the sediment and by November 1976 the *Limecola balthica* population had recovered to 51 individuals/m^2. One year later there was no detectable difference in the *Limecola balthica* population between the recently dredged area and a reference area elsewhere in the bay. In 1976, two generations could be detected in the newly established population indicating that active immigration of adults was occurring in parallel to larval settlement. In 1977, up to six generations were identified, giving further evidence of active immigration to the dredged area. In light of the life history characteristics of *Limecola balthica* and the evidence of recovery, recoverability of the species is assessed as high.

Importance review

Policy/legislation

- no data -

Status

National (GB) importance	-	**Global red list (IUCN) category**	-

Non-native

Native	-		
Origin	-	**Date Arrived**	-

Importance information

Limecola balthica is classed as a biodestabiliser. Widdows *et al*. (2000) found a significant relationship between sediment erodability (mass of sediment eroded and erosion rate) and the density of *Limecola balthica*.

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